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Mishina et al.

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(54) **REDUCED SIZE IMAGE PICKUP APPARATUS
RETAINING IMAGE QUALITY INCLUDING A
PLURALITY OF PHOTOELECTRIC
CONVERSION CIRCUITS OF DIFFERENT
ROWS AND DIFFERENT COLUMNS
SHARING AT LEAST ONE PIXEL
TRANSISTOR**

(58) **Field of Classification Search**

CPC H04N 5/374; H04N 5/37457; H04N
5/37455; H04N 5/3742; H04N 5/3745
USPC 348/301, 302, 308
See application file for complete search history.

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(57) **ABSTRACT**

An image pickup apparatus for photographing an image, includes: a photoelectric converter to convert incident light an electric charge and accumulate the electric charge, a transfer element to transfer the electric charge accumulated in the photoelectric converter, a converter to convert the electric charge in the photoelectric converter transferred via the transfer element into a voltage, a reset element to reset potentials of the converter, and an amplifier to amplify a voltage converted by the converter to generate a pixel signal and output the pixel signal to a read signal line for reading the pixel signal. A plurality of the photoelectric converter and the transfer element are disposed at least in a horizontal direction share the amplifier and the read signal line.

22 Claims, 11 Drawing Sheets

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Aug. 19, 2008, now Pat. No. 8,698,928.

(30) **Foreign Application Priority Data**

Aug. 21, 2007 (JP) 2007-214484

(51) **Int. Cl.**

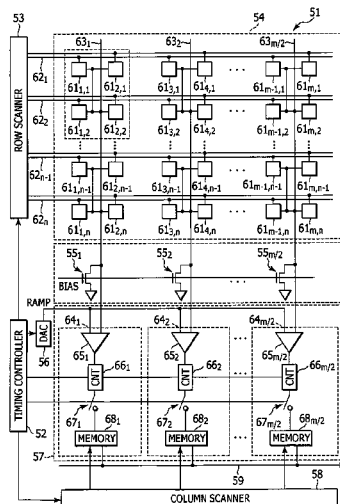
H04N 5/378 (2011.01)

H04N 5/374 (2011.01)

H04N 5/3745 (2011.01)

(52) **U.S. Cl.**

CPC **H04N 5/378** (2013.01); **H04N 5/3742**
(2013.01); **H04N 5/37457** (2013.01)



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FIG. 1

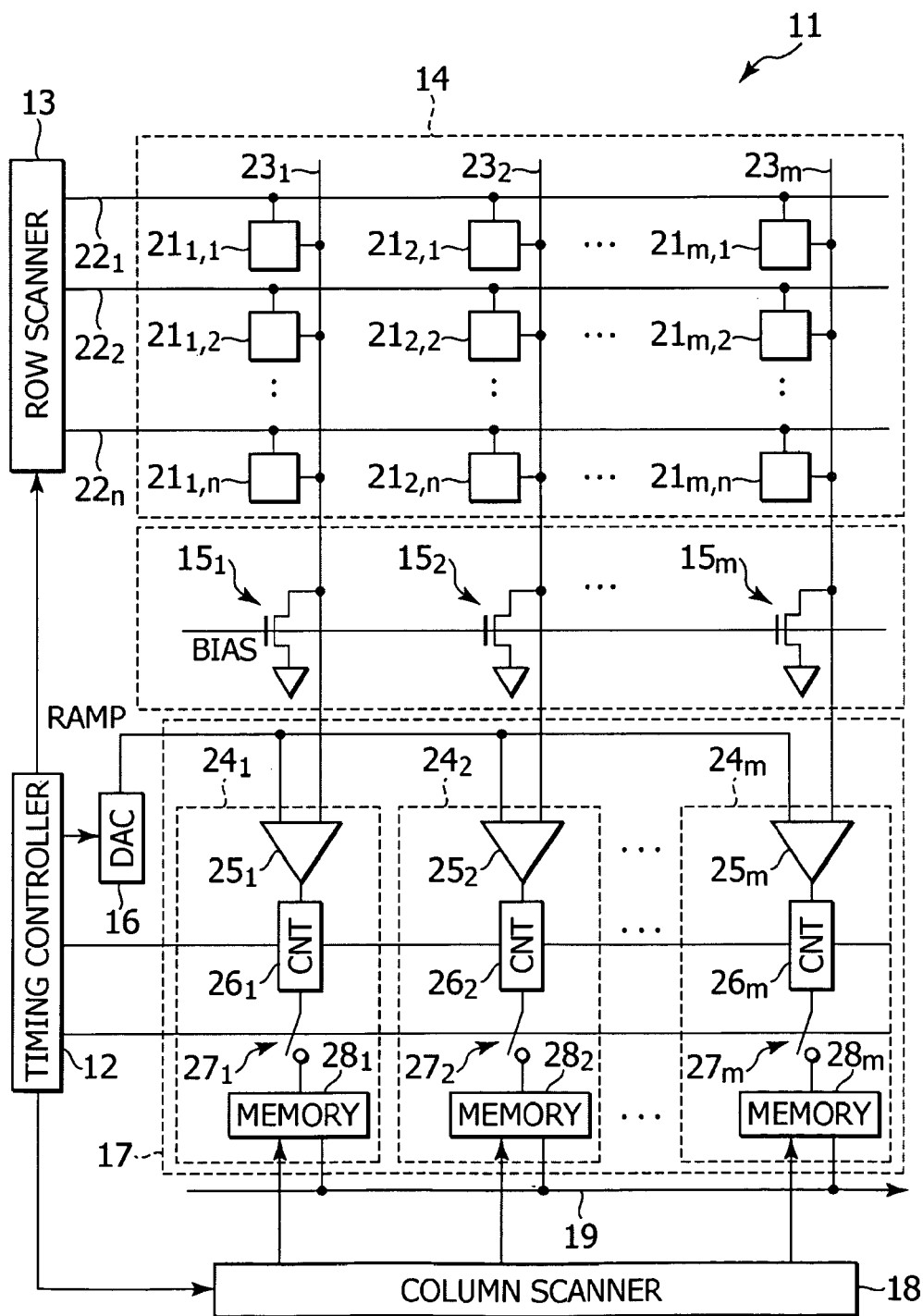
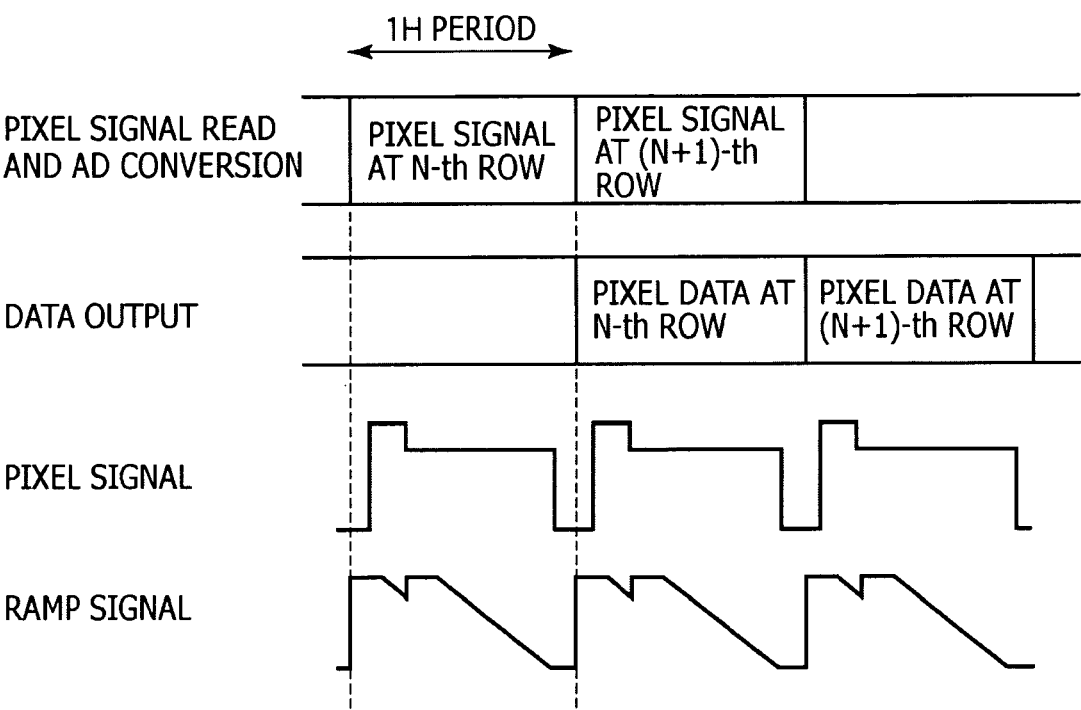


FIG. 2



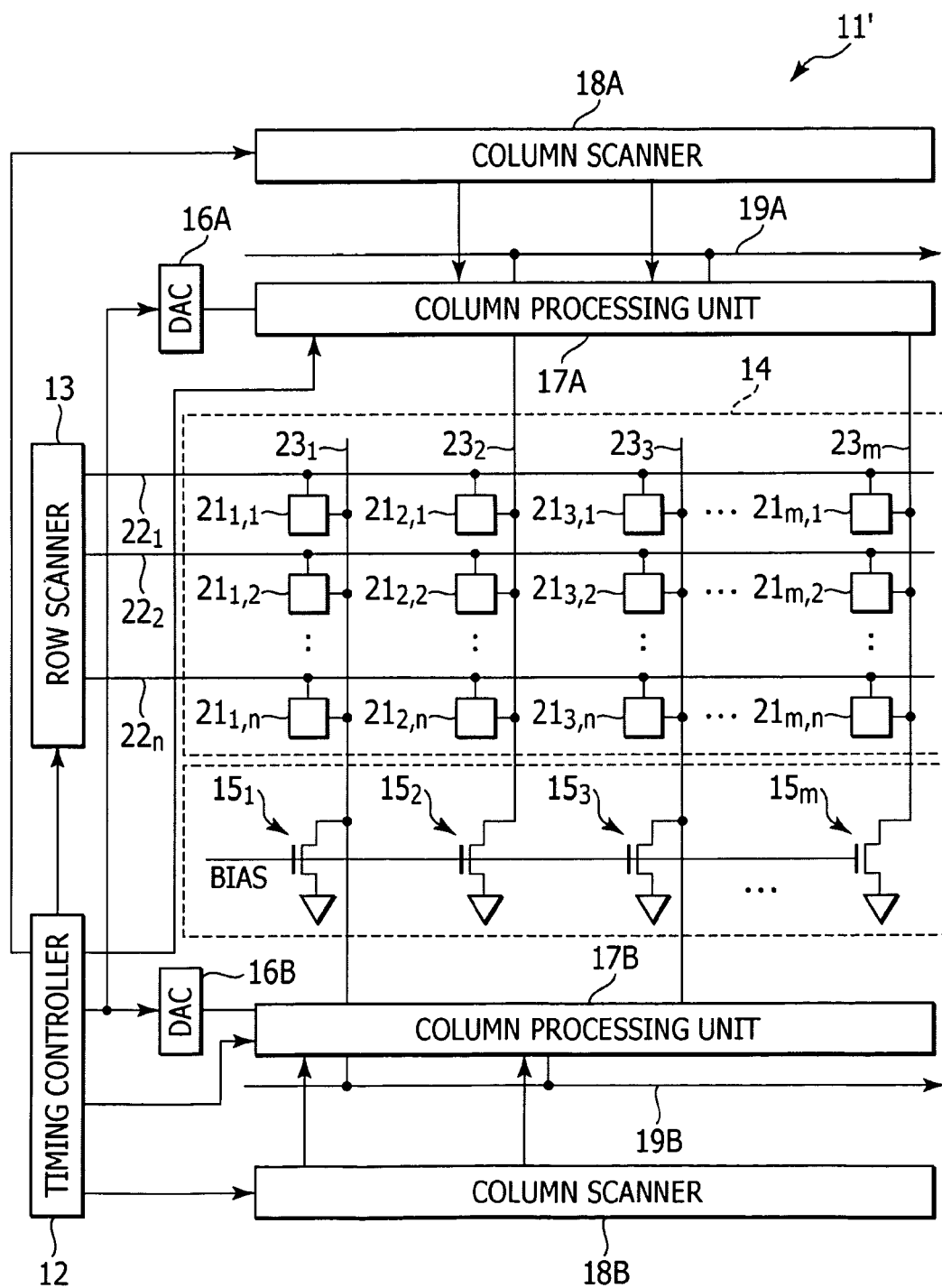


FIG. 4

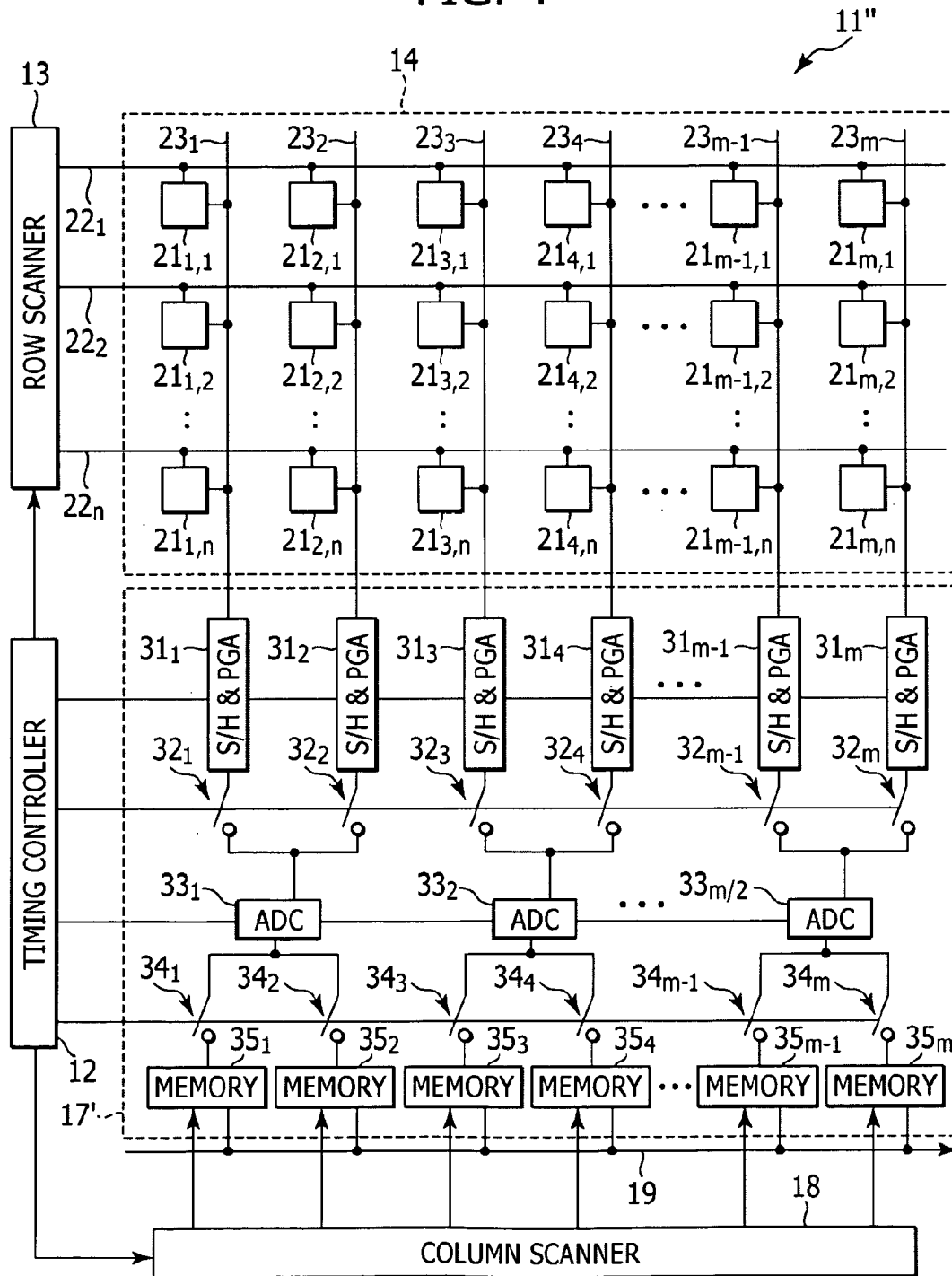


FIG. 5

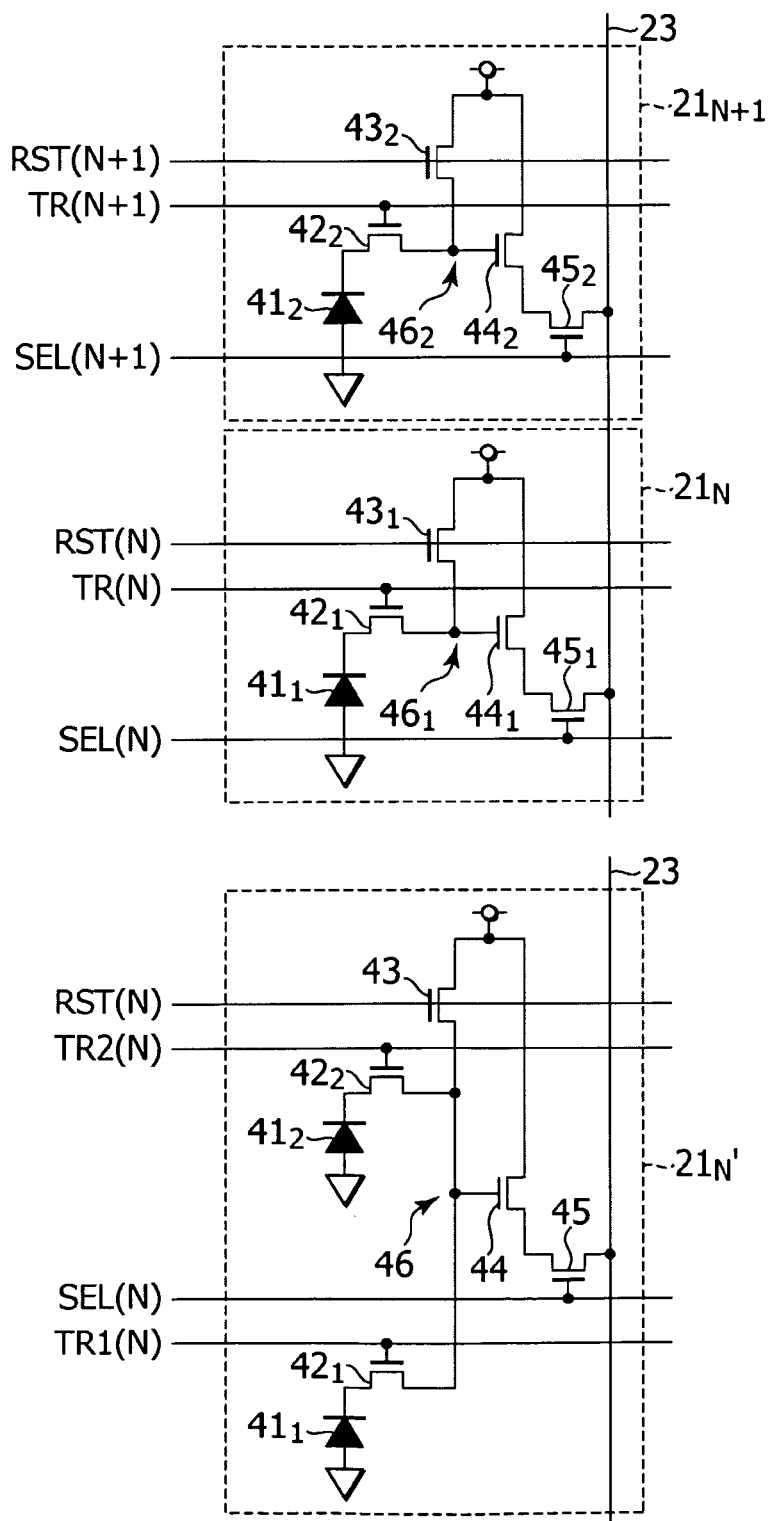


FIG. 6

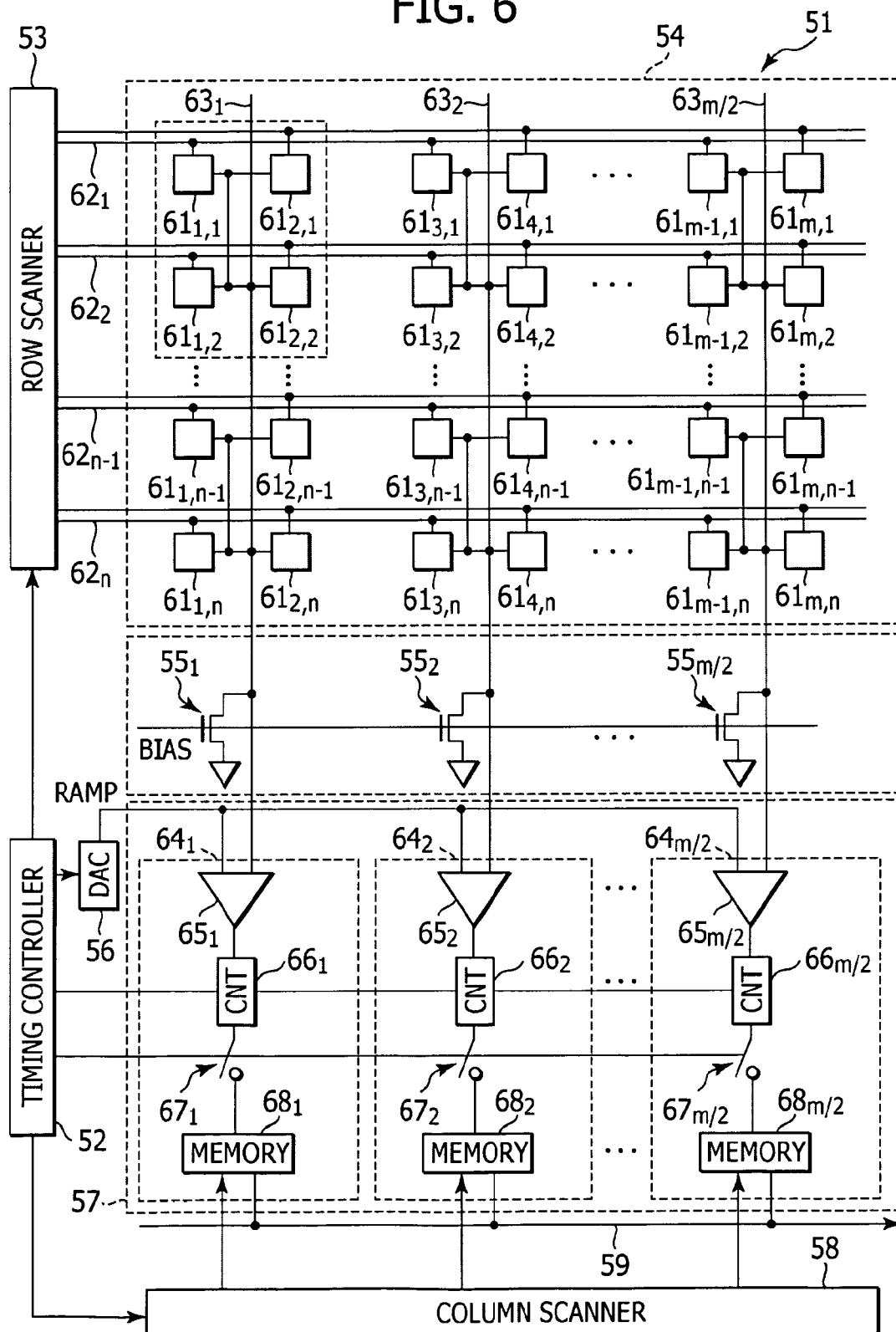


FIG. 7

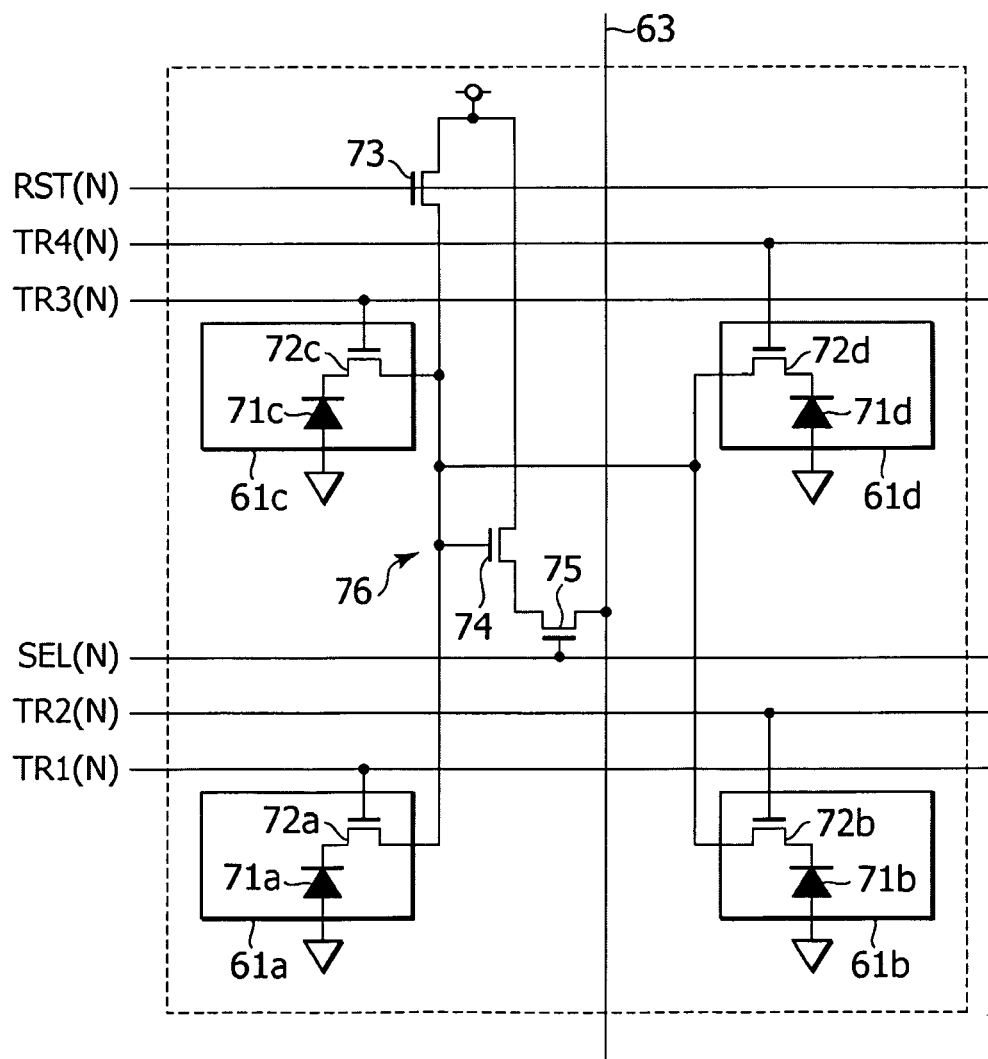


FIG. 8

1H PERIOD

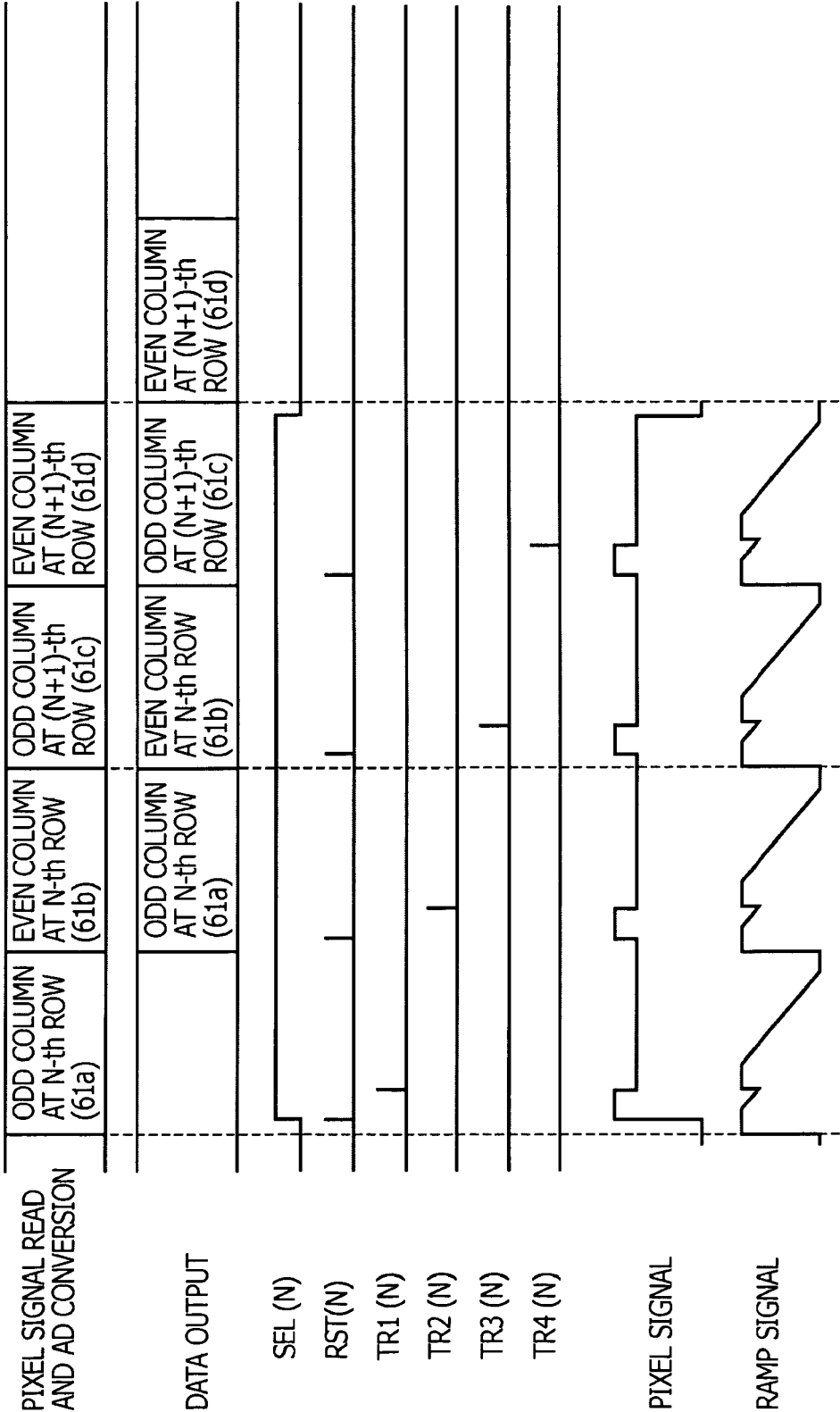


FIG. 9

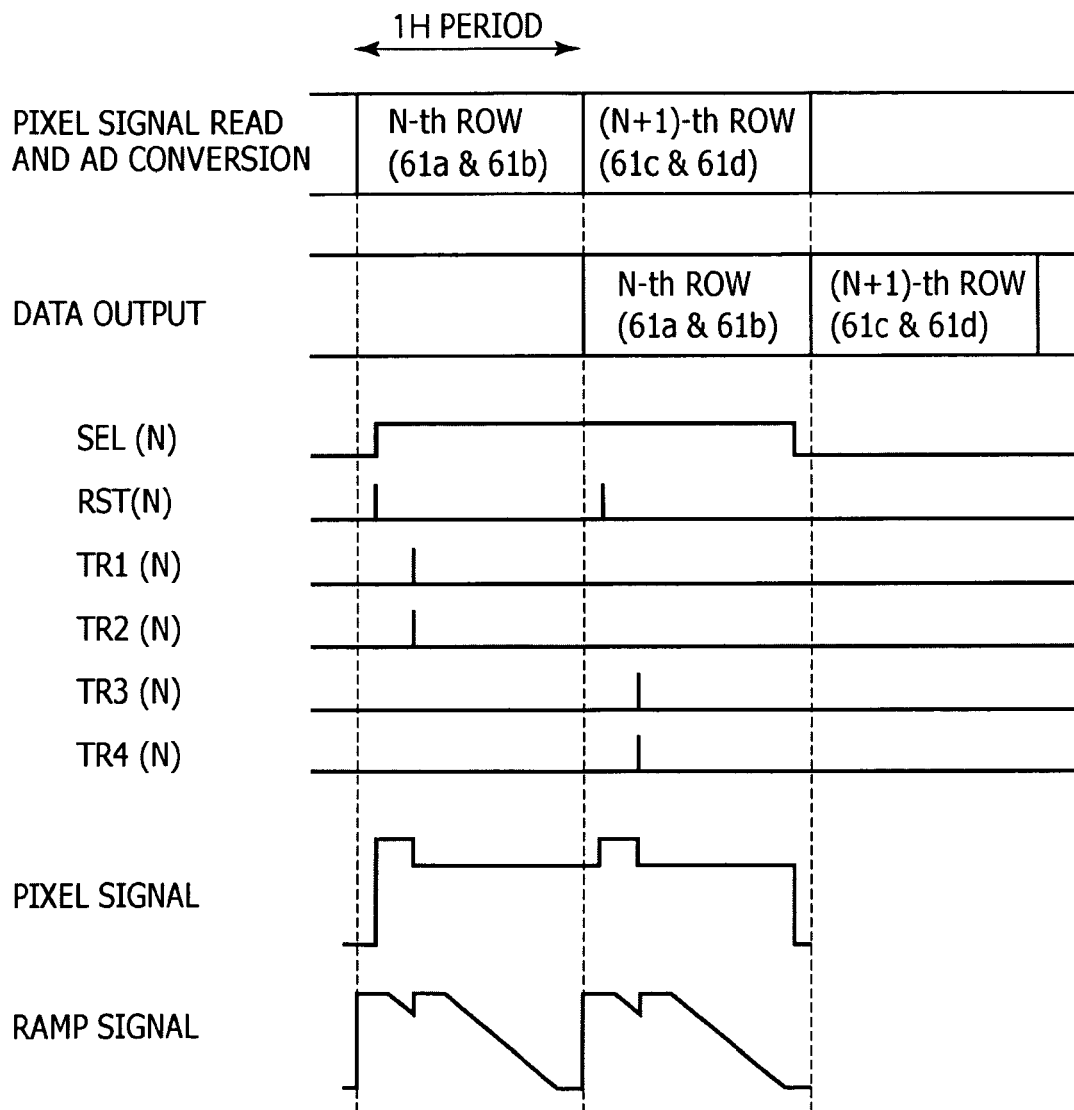


FIG. 10

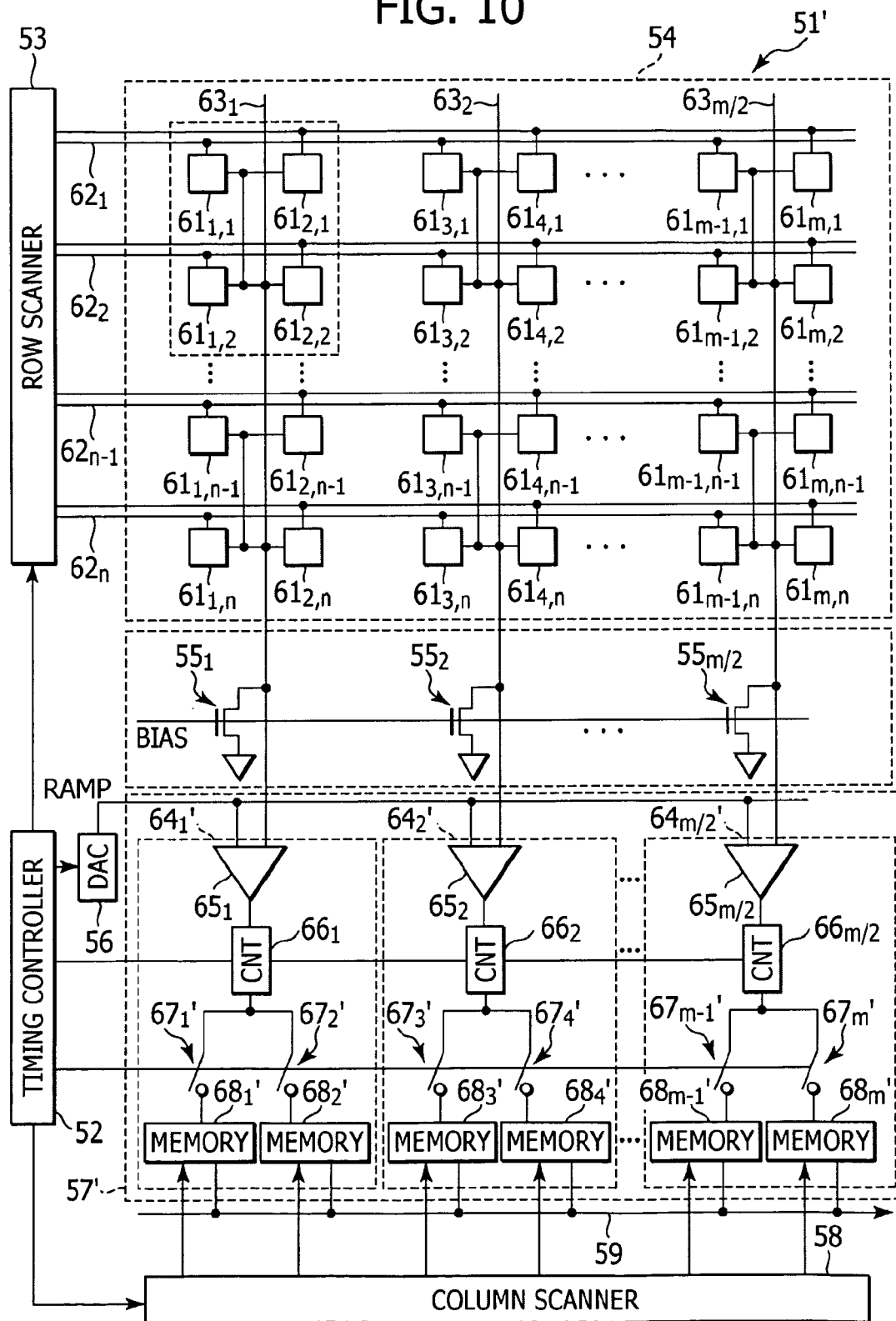
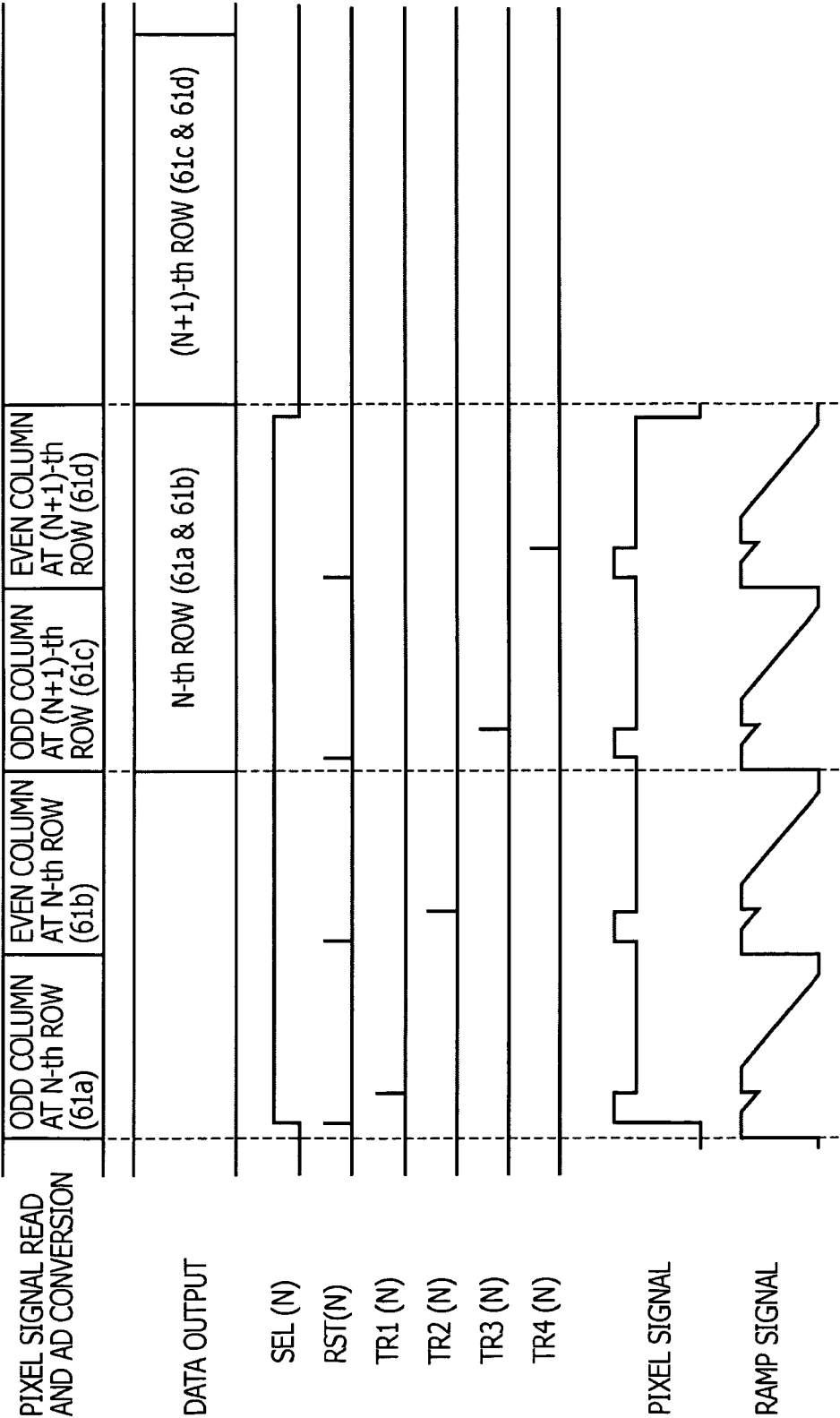


FIG. 11

1H PERIOD



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**REDUCED SIZE IMAGE PICKUP APPARATUS
RETAINING IMAGE QUALITY INCLUDING A
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**CROSS-REFERENCE TO RELATED
APPLICATIONS**

This application is a continuation of U.S. patent application Ser. No. 12/194,176, filed Aug. 19, 2008, which claims priority to Japanese patent Application No. 2007-214484, filed in the Japanese Patent Office on Aug. 21, 2007, the entire contents of which are hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image pickup apparatus.

2. Description of Related Art

A charge coupled device (CCD), a complementary metal oxide semiconductor (CMOS) sensor and the like have been used as an image pickup device, and using a plurality of pixels and making compact an image pickup device is under progress.

The increase in the number of pixels and the miniaturization of image pickup device make a unit cell size of pixels small, increase a ratio of a transistor area to a pixel area, and make the area of photodiodes small. As a result, the saturated charge amount and the sensitivity of each pixel may be lowered and an image quality may be degraded.

Japanese Unexamined Patent Application Publication No. 2006-340044 discloses a CMOS sensor (hereinafter called a CMOS sensor mounting column parallel analog to digital converters (ADCs) where applicable) having an ADC disposed every columns of pixels formed in a matrix shape, the ADCs being disposed in parallel.

FIG. 1 is a block diagram showing an example of the structure of a CMOS sensor mounting column parallel ADCs.

In FIG. 1, a CMOS sensor 11 includes a timing control circuit 12, a row scanner 13, a pixel array 14, m load MOSs 15₁ to 15_m, a DAC (Digital Analog Converter) 16, a column processing unit 17, a column scanner 18, and a horizontal output line 19.

On the basis of a master clock having a predetermined frequency, the timing control circuit 12 supplies the row scanner 13, DAC 16, column processing unit 17, and column scanner 18, with a clock signal, a timing signal and the like necessary for the operations of these components.

The row scanner 13 sequentially supplies a signal for controlling the output of a pixel signal, to pixels disposed in a vertical direction of the pixel array 14, at a predetermined timing.

The pixel array 14 has pixels 21_{1,1} to 21_{m,n} having m columns and n rows: n horizontal signal lines 22₁ to 22_n and m vertical signal lines 23₁ to 23_m.

Each of the pixels 21_{1,1} to 21_{m,n} includes a photodiode (not shown). A pixel signal corresponding to an electric charge accumulated in each photodiode is outputted to each of the vertical signal lines 23₁ to 23_m in response to a signal supplied from the row scanner 13 via each of the horizontal signal lines 22₁ to 22_n.

The horizontal lines 22₁ to 22_n connect the row scanner 13 to the pixels 21_{1,1} to 21_{m,n} in a horizontal direction. Namely,

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the pixels 21_{1,1} to 21_{m,1} are connected to the horizontal signal line 22₁, the pixels 21_{1,2} to 21_{m,2} are connected to the horizontal signal line 22₂, and in a similar manner to follow, the pixels 21_{1,n} to 21_{m,n} are connected to the horizontal signal line 22_n.

The vertical signal lines 23₁ to 23_m connect the column processing unit 17 to the pixels 21_{1,1} to 21_{m,n} in a vertical direction. Namely, the pixels 21_{1,1} to 21_{1,n} are connected to the vertical signal line 23₁, the pixels 21_{2,1} to 21_{2,n} are connected to the vertical signal line 23₂, and in a similar manner to follow, the pixels 21_{m,1} to 21_{m,n} are connected to the vertical signal line 23_m.

Drains of the load MOSs 15₁ to 15_m are connected to the vertical signal lines 23₁ to 23_m. A bias voltage is applied to the gates, and the sources are grounded. The load MOS and an amplifying transistor (not shown) in each of the pixels 21_{1,1} to 21_{m,n} constitute a source follower circuit.

In accordance with a timing signal or the like from the timing control circuit 12, DAC 16 generates a ramp signal (having a waveform shown in FIG. 2 to be described later) and supplies the ramp signal to the column processing unit 17.

The column processing unit 17 includes ADCs 24₁ to 24_m disposed in parallel, wherein the number of ADCs is m.

The ADCs 24₁ to 24_m are connected to the vertical signal lines 23₁ to 23_m, respectively, and perform A/D conversion of pixel signals supplied via the vertical signal lines 23₁ to 23_m by using a ramp signal supplied from DAC 16.

The ADCs 24₁ to 24_m each includes a comparator, a counter, a switch, and a memory. Namely, ADC 24₁ includes a comparator 25₁, a counter (CNT) 26₁, a switch 27₁, and a memory 28₁. The ADC 24₂ includes a comparator 25₂, a counter 26₂, a switch 27₂, and a memory 28₂, and in a similar manner to follow, ADC 24_m includes a comparator 25_m, a counter 26_m, a switch 27_m, and a memory 28_m.

Pixel signals are supplied from the pixels 21_{m,1} to 21_{m,n} to the comparators 25₁ to 25_m, respectively, via the vertical signal lines 23₁ to 23_m. The ramp signals from DAC 16 are supplied to the comparators 25₁ to 25_m, respectively.

The comparators 25₁ to 25_m compare the ramp signal supplied from DAC 16 with the pixel signals supplied via the vertical signal lines 23₁ to 23_m, and supply comparison signals representative of the comparison results to the counters 16₁ to 26_m. Namely, the comparator 25₁ supplies a comparison signal between the ramp signal from DAC 16 and the pixel signal supplied from the pixels 21_{1,1} to 21_{1,n} via the vertical signal line 23₁, to the counter 26₁. The comparator 25₂ supplies a comparison signal between the ramp signal from DAC 16 and the pixel signal supplied from the pixels 21_{2,1} to 21_{2,n} via the vertical signal line 23₂, to the counter 26₂, and in a similar manner to follow, the comparator 25_m supplies a comparison signal between the ramp signal from DAC 16 and the pixel signal supplied from the pixels 21_{m,1} to 21_{m,n} via the vertical signal line 23_m, to the counter 26_m.

The counters 26₁ to 26_m are supplied with a clock signal from the timing control circuit 12, and count the clock signals on the basis of the comparison signal from the comparators 25₁ to 25_m. The count values representative of the count results of clock signals by the counters 26₁ to 26_m are supplied to the memories 28₁ to 28_m via the switches 27₁ to 27_m, as pixel data obtained by A/D conversion of the pixel signal.

In response to the timing signal from the timing control circuit 12, the switches 27₁ to 27_m connect the counters 26₁ to 26_m and the memories 28₁ and 28_m.

The memories 28₁ to 28_m temporarily store the pixel data supplied from the counters 26₁ to 26_m, and output the pixel data to the horizontal output line 19 under control of the column scanner 18.

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The column scanner 18 sequentially outputs the pixel data stored in the memories 28₁ to 28_m to the horizontal output line 19 at a predetermined timing.

The horizontal output line 19 is connected to an image processing circuit or the like at the succeeding stage, and supplies the pixel data outputted from the memories 28₁ to 28_m to an image processing circuit and the like.

FIG. 2 is a timing chart illustrating the operation of the CMOS sensor 11 shown in FIG. 1.

For example, as shown in the uppermost field of FIG. 2, during a 1 H period (one horizontal scan period), a pixel signal is read from a pixel 21_N at the N-th row, and A/D converted by the column processing unit 17. During the next 1 H period, while a pixel signal is read from a pixel 21_{N+1} at the (N+1)-th row, pixel data obtained by A/D conversion of the pixel signal at the N-th row is outputted as shown in the second uppermost field of FIG. 2.

The pixel signal read from the pixel 21 has a waveform shown in the third field of FIG. 2, and the ramp signal outputted from DAC 16 has a waveform shown in the fourth (lowermost) field of FIG. 2. The comparator 25 in FIG. 1 compares the ramp signal with the pixel signal having these waveforms.

As described above, in the CMOS sensor 11, ADCs 24₁ to 24_m are disposed at a pitch similar to that of the pixels 21_{1,1} to 21_{m,n} in the horizontal direction. As a result, the ADCs 24₁ to 24_m perform A/D conversion of the pixel signals in parallel. As described above, as the CMOS sensor 11 mounting column parallel ADCs is made compact in recent years, the pixel array 14 is becoming small. Accordingly, a pitch of the pixels 21_{1,1} to 21_{m,n} in the horizontal direction becomes narrow, so that it is difficult to dispose ADCs 24₁ to 24_m at the same pitch as that of the pixels.

Consequently, for example, the column processing unit 17 is disposed in two areas. As a result, the ADCs 24₁ to 24_m can be disposed at a pitch wider than that of the pixels 21_{1,1} to 21_{m,n} in the horizontal direction.

FIG. 3 is a block diagram showing an example of the structure of a CMOS sensor 11' having two column processing units 17A and 17B.

In FIG. 3, the CMOS sensor 11' includes a timing control circuit 12, a row scanner 13, a pixel array 14, m load MOSs 15₁ to 15_m, two DACs 16A and 16B, two column processing units 17A and 17B, two column scanners 18A and 18B, and two horizontal output lines 19A and 19B.

As shown in FIG. 3, in the CMOS sensor 11' mounting column parallel ADCs, the column processing units 17A and 17B are disposed to sandwich the pixel array 14 in the vertical direction (up/down).

Although the column processing unit 17 shown in FIG. 1 includes m ADCs 24₁ to 24_m, the column processing units 17A and 17B have each m/2 ADCs (not shown). Namely, the column processing unit 17A is provided with ADCs for A/D conversion of pixel signals at even columns among pixel signals read from the pixels 21_{1,1} to 21_{m,n}. The column processing unit 17B is provided with ADCs for A/D conversion of pixel signals at odd columns among pixel signals read from the pixels 21_{1,1} to 21_{m,n}.

In the column processing units 17A and 17B, ADCs may therefore be disposed at a pitch twice that of the pixels 21_{1,1} to 21_{m,n} in the horizontal direction.

The two column processing units 17A and 17B may be disposed sandwiching the pixel array 14 in the horizontal direction, or may be disposed on the same side of the pixel array 14 at two stages.

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The two column processing units 17A and 17B of the CMOS sensor 11' may have different characteristics. In this case, a photographed image may show vertical stripes, which degrades the image quality.

For example, Japanese Unexamined Patent Application Publication No. 2006-80861 discloses a CMOS sensor in which one ADC A/D converts pixels of a plurality of columns so that ADCs can be disposed at a broader pitch than that of pixels in the horizontal direction.

FIG. 4 is a block diagram showing an example of the structure of a CMOS sensor 11" in which one ADC A/D converts pixel signals of two columns.

In FIG. 4, the CMOS sensor 11" includes a timing control circuit 12, a row scanner 13, a pixel array 14, a column processing unit 17', a column scanner 18, and a horizontal output line 19.

The structure of the column processing unit 17' of the CMOS sensor 11" shown in FIG. 4 is different from that of the column processing unit 17 of the CMOS sensor 11 shown in FIG. 1.

Namely, the column processing unit 17' includes capacitors the number of which is m, 31₁ to 31_m, switches the number of which is m, 32₁ to 32_m, ADCs the number of which is m/2, 33₁ to 33_{m/2}, switches the number of which is m, 34₁ to 34_m, and memories the number of which is m, 35₁ to 35_m.

The capacitors 31₁ to 31_m are connected to the vertical signal lines 23₁ to 23_m, respectively, and hold pixel signals supplied via the vertical signal lines 23₁ to 23_m.

The switches 32₁ to 32_m switch the connection between the capacitors 31₁ to 31_m and ADCs 33₁ and 33_{m/2}. For example, the switch 32₁ switches the connection between the capacitor 31₁ and ADC 33₁ and the connection between the capacitor 31₂ and ADC 33₁. When the capacitor 31₁ is coupled to ADC 33₁, the pixel signal held in the capacitor 31₁ is supplied to ADC 33₁. When the capacitor 31₂ is coupled to ADC 33₁, the pixel signal held in the capacitor 31₂ is supplied to ADC 33₁.

The ADCs 33₁ to 33_{m/2} A/D convert the pixel signals supplied from the capacitors 31₁ to 31_m. Namely, ADC 33₁ A/D converts the pixel signal supplied from the capacitors 31₁ and 31₂. The ADC 33₂ performs A/D conversion of the pixel signal supplied from the capacitors 31₃ and 31₄, and in a similar manner to follow, ADC 33_{m/2} performs A/D conversion of the pixel signal supplied from the capacitors 31_{m-1} and 31_m.

The switches 34₁ to 34_m switch the connection between ADC 33₁ to 33_{m/2} and the memories 35₁ to 35_m. For example, at the timing when ADC 33₁ A/D converts the pixel signal supplied via the vertical signal line 23₁, the switch 34₁ connects ADC 33₁ and memory 35₁. At the timing when ADC 33₁ performs A/D conversion of the pixel signal supplied via the vertical signal line 23₂, the switch 34₂ connects ADC 33₂ and memory 35₂.

The memories 35₁ to 35_m temporarily store pixel data output from ADCs 33₁ to 33_{m/2}, and output the pixel data to the horizontal output line 19 under control of the column scanner 18.

In the CMOS sensor 11" constructed as above, ADCs 33₁ to 33_{m/2} can be disposed at a pitch twice that of the pixels 21_{1,1} to 21_{m,n} in the horizontal direction.

In the CMOS sensor 11", the capacitors 31₁ to 31_m hold analog pixel signals read from the pixels 21_{1,1} to 21_{m,n}. There may be a variation in leakage of pixel signals in the capacitors 31₁ to 31_m, if there is a variation in capacitances of the capacitors 31₁ to 31_m or a difference of the time from when the pixel signal is held to when the pixel signal is supplied to the ADCs 33₁ to 33_{m/2}. The quality of an image photographed with the CMOS sensor 11" may therefore be degraded.

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As described above, as the unit cell size of a pixel becomes small, the area of a photodiode becomes small, and the image quality is degraded if the saturated electric charge amount and a sensitivity of a pixel are reduced.

As a method of avoiding the reduction in the saturated electric charge amount and sensitivity, there is a method of sharing a floating diffusion by using pixels in the vertical direction.

With reference to FIG. 5, description will be made on sharing a floating diffusion.

The upper area of FIG. 5 shows pixels 21_N and 21_{N+1} having a structure that a floating diffusion is not shared. The lower area of FIG. 5 shows a pixel $21_N'$ having a structure that a floating diffusion is shared.

As shown in FIG. 5, the pixel 21_N includes a photodiode 41_1 , a transfer transistor 42_1 , a reset transistor 43_1 , an amplifying transistor 44_1 , a select transistor 45_1 , and a floating diffusion 46_1 .

The electric charge corresponding to a light reception amount of the photodiode 41_1 is transferred to the floating diffusion 46_1 via the transfer transistor 42_1 , and accumulated therein. The floating diffusion 46_1 is clamped to a predetermined reference potential by the reset transistor 43_1 , and the electric charge accumulated in the reset transistor 43_1 is amplified by the amplifying transistor 44_1 and outputted to the vertical signal line 23 via the select transistor 45_1 .

Similar to the pixel 21_N , the pixel 21_{N+1} includes a photodiode 41_2 , a transfer transistor 42_2 , a reset transistor 43_2 , an amplifying transistor 44_2 , a select transistor 45_2 , and a floating diffusion 46_2 .

The pixel $21_N'$ includes photodiodes 411 and 412 , transfer transistors 421 and 422 , a reset transistor 43 , an amplifying transistor 44 , a select transistor 45 , and a floating diffusion 46 . In the pixel $21_N'$, the electric charge corresponding to the light reception amount of the photodiode 411 and the electric charge corresponding to the light reception amount of the photodiode 412 are alternately accumulated in the floating diffusion 46 .

Thus, the pixel $21_N'$ shares the floating diffusion 46 so that it is possible to avoid the reduction in the saturated charge amount and sensitivity of a pixel.

However, in a CMOS sensor having a pixel array constituted of pixels sharing a floating diffusion, ADCs are disposed at the same pitch as that of pixels.

SUMMARY OF THE INVENTION

As described above, as a CMOS sensor is made compact, it is difficult to dispose ADCs at the same pitch as that of pixels. An image quality lowers because of the reduction in the saturated charge amount and sensitivity of a pixel.

Accordingly, it is desirable to suppress the image quality from being lowered by a compact CMOS sensor.

In accordance with one aspect of the present invention, there is provided an image pickup apparatus which includes a photoelectric converter, a transfer element, a converter, a reset element, and an amplifier. The photoelectric converter converts incident light into an electric signal and accumulates the electric signal. The transfer element transfers the electric charge accumulated in the photoelectric converter. The converter converts the electric charge in the photoelectric converter transferred via the transfer element into a voltage. The reset element resets a potential of the converter. The amplifier amplifies a voltage converted by the converter to generate a pixel signal and outputs the pixel signal to a read signal line for reading the pixel signal. A plurality of the photoelectric

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converter and the transfer element disposed at least in a horizontal direction share the amplifier and the read signal line

According to an embodiment of the present invention, it is possible to suppress the image quality from being lowered by a compact CMOS sensor.

The above summary of the present invention is not intended to describe each illustrated embodiment or every implementation of the present invention. The figures and the detailed description which follow more particularly exemplify these embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing an example of the structure of a CMOS sensor mounting column parallel ADCs.

FIG. 2 is a timing chart explaining the operation of a CMOS sensor 11.

FIG. 3 is a timing chart explaining the operation of a CMOS sensor 11'.

FIG. 4 is a timing chart explaining the operation of a CMOS sensor 11".

FIG. 5 is a diagram explaining a shared floating diffusion.

FIG. 6 is a block diagram showing an example of the structure of a CMOS sensor according to an embodiment of the present invention.

FIG. 7 is a diagram explaining a 2x2 sharing pixel constituted of four pixels.

FIG. 8 is a timing chart illustrating an example of the operation of a CMOS sensor 51.

FIG. 9 is a timing chart illustrating another example of the operation of the CMOS sensor 51.

FIG. 10 is a block diagram showing an example of the structure of a CMOS sensor according to another embodiment.

FIG. 11 is a timing chart illustrating an example of the operation of a CMOS sensor 51'.

DETAILED DESCRIPTION OF EMBODIMENTS

In the following description of embodiments of the present invention, the correspondence between the disclosed inventions and the embodiments is as follows. The description is used for confirming that the embodiments supporting the inventions described in this specification are described in this specification as not corresponding to some invention is not intended to mean that the embodiment does not correspond to the invention. Conversely, the embodiment described in this specification as corresponding to some invention is not intended to mean that the embodiment does not correspond to the invention other than some invention.

According to one embodiment of the present invention, an image pickup apparatus for photographing an image is provided, which includes:

a photoelectric converter (e.g., photodiode $71a$, $71b$, $71c$, $71d$ in FIG. 7) for converting incident light into an electric signal and accumulating the electric charge;

a transfer element (e.g., a transfer transistor $72a$, $72b$, $72c$, $72d$ in FIG. 7) for transferring the electric charge accumulated in the photoelectric converter;

a converter (e.g., a floating diffusion 76 in FIG. 7) for converting the electric charges in the photoelectric converter transferred via the transfer element into a voltage;

a reset element (e.g., a reset transistor 74 in FIG. 7) for resetting potentials of the converter; and

an amplifier (e.g., an amplifying transistor 74 in FIG. 7) for amplifying the voltage converted by the converter and out-

putting a pixel signal obtained by amplifying the voltage to a read signal line for reading the pixel signal,

wherein a plurality of the photoelectric converter and the transfer element disposed at least in a horizontal direction share the amplifier and the read signal line.

The image pickup apparatus according to an embodiment of the present invention may further include a control line (e.g., horizontal signal lines 62_1 to 62_n in FIG. 6) for transmitting a signal for controlling a transfer of the electric charge by the transfer element, wherein the control line is independent for each of the plurality of the transfer element sharing the amplifier and the read signal line.

The image pickup apparatus according to an embodiment of the present invention may further include a load metal oxide semiconductor (MOS) (e.g., load MOSs 55_1 to $55_{m/2}$ in FIG. 6) connected to the read signal line, and the load MOS and the amplifier constitute a source follower circuit.

The image pickup apparatus according to an embodiment of the present invention may further include an analog to digital (A/D) converter (e.g., ADCs 64_1 to $64_{m/2}$ in FIG. 6) for converting the pixel signal read via the read signal line into a digital signal.

In the image pickup apparatus according to an embodiment of the present invention, the A/D converter may further include:

comparison elements e.g., comparators 65_1 to $65_{m/2}$ in FIG. 6) having a first input terminal for receiving the pixel signal and a second input terminal for receiving a reference voltage lowering from a predetermined reference potential at a constant slope, wherein the comparison element compares the pixel signal inputted to the first input terminal with the reference voltage inputted to the second input terminal, after potentials at the first and second input terminals are reset; and measurement elements (e.g., counters 66_1 to $66_{m/2}$ in FIG. 6) for measuring a time from when the reference voltage starts lowering from the predetermined reference potential at the constant slope to when the comparison element judges that the reference voltage becomes lower than the pixel signal.

With reference to the accompanying drawings, specific embodiments adopting the present invention will be described in detail.

FIG. 6 is a block diagram showing an example of the structure of a CMOS sensor according to an embodiment employing the present invention.

In FIG. 6, a CMOS sensor 51 includes a timing control circuit 52, a row scanner 53, a pixel array 54, $m/2$ load MOSs 55_1 to $55_{m/2}$, a DAC 56, a column processing unit 57, a column scanner 58, and a horizontal output line 59.

On the basis of a master clock having a predetermined frequency, the timing control circuit 52 supplies the row scanner 53, DAC 56, column processing unit 57, and column scanner 58, with a clock signal, a timing signal, and the like necessary for the operations of these components.

The row scanner 53 sequentially supplies a signal for controlling the output of a pixel signal to pixels disposed in a vertical direction of the pixel array 54, at a predetermined timing.

The pixel array 54 includes pixels $61_{1,1}$ to $61_{m,n}$ having m columns and n rows: n horizontal signal lines 62_1 to 62_n and m vertical signal lines 63_1 to $63_{m/2}$.

Each of the pixels $61_{1,1}$ to $61_{m,n}$ includes a photodiode 71 and a transfer transistor 72, as will be later described with reference to FIG. 7. Four pixels of two horizontal pixels and two vertical pixels share a reset transistor 73, an amplifying transistor 74, a select transistor 75, and a floating diffusion 76.

In this example, a pixel as a constituent element of an image photographed with the CMOS sensor 51 is defined as

a pixel 61 having the photodiode 71 for photoelectric conversion and the transfer transistor 72 for transferring electric charges. However, a hardware pixel includes not only the photodiode and transfer transistor, but also the reset transistor, amplifying transistor, select transistor, and floating diffusion. A component constituted of, e.g., four pixels of two horizontal pixels and two vertical pixels, a reset transistor, an amplifying transistor, a select transistor, and a floating diffusion is called hereinafter “ 2×2 sharing pixel” where applicable.

Namely, for example, the pixels $61_{1,1}$, $61_{2,1}$, $61_{1,2}$ and $61_{2,2}$ surrounded by a broken line in FIG. 6 constitute one 2×2 sharing pixel, the pixels $61_{3,1}$, $61_{4,1}$, $61_{3,2}$ and $61_{4,2}$ constitute one 2×2 sharing pixel, and in a similar manner to follow, the pixels $61_{m-1,n-1}$, $61_{m,n-1}$, $61_{m-1,n}$, and $61_{m,n}$ constitute one 2×2 sharing pixel.

The pixels $61_{1,1}$ to $61_{m,n}$ output pixel signals corresponding to electric charges accumulated in photodiodes 61 of two columns at a time to one vertical signal line 63. Namely, the pixels $61_{1,1}$ to $61_{1,n}$ of the first column and the pixels $61_{2,1}$ to $61_{2,n}$ of the second column output pixel signals to the vertical signal line 63₁, the pixels $61_{3,1}$ to $61_{3,n}$ of the third column and the pixels $61_{4,1}$ to $61_{4,n}$ of the fourth column output pixel signals to the vertical signal line 63₂, and in a similar manner to follow, the pixels $61_{m-1,1}$ to $61_{m-1,n}$ of the $(m-1)$ -th column and the pixels $61_{m,1}$ to $61_{m,n}$ of the m -th column output pixel signals to the vertical signal line 63 _{$m/2$} .

The horizontal lines 62_1 to 62_n connect the row scanner 63 to the pixels $61_{1,1}$ to $61_{m,n}$ in a horizontal direction. Namely, the pixels $61_{1,1}$ to $61_{m,1}$ are connected to the horizontal signal line 62₁, the pixels $61_{1,2}$ to $61_{m,2}$ are connected to the horizontal signal line 62₂, and in a similar manner to follow, the pixels $61_{1,n}$ to $61_{m,n}$ are connected to the horizontal signal line 62 _{n} .

The vertical signal lines 63₁ to 63 _{$m/2$} connect the column processing unit 57 to the pixels $61_{1,1}$ to $61_{m,n}$ of two columns in a vertical direction. Namely, the pixels $61_{1,1}$ to $61_{1,n}$ and the pixels $61_{2,1}$ to $61_{2,n}$ are connected to the vertical signal line 63₁, the pixels $61_{3,1}$ to $61_{3,n}$ and the pixels $61_{4,1}$ to $61_{4,n}$ are connected to the vertical signal line 63₂, and in a similar manner to follow, the pixels $61_{m-1,1}$ to $61_{m-1,n}$ and the pixels $61_{m,1}$ to $61_{m,n}$ are connected to the vertical signal line 63 _{m} .

The drains of the load MOSs 55_1 to $55_{m/2}$ are connected to the vertical signal lines 63₁ to 63 _{$m/2$} ; a bias voltage is applied to the gates, and the sources are grounded. The load MOS and an amplifying transistor 74 (FIG. 7) in each of the pixels $61_{1,1}$ to $61_{m,n}$ constitute a source follower circuit.

In accordance with a timing signal or the like from the timing control circuit 52, DAC 56 generates a ramp signal and supplies the ramp signal to the column processing unit 57.

In the column processing unit 57, $m/2$ ADCs 64_1 to $64_{m/2}$ are disposed in parallel.

The ADCs 64_1 to $64_{m/2}$ are connected to the vertical signal lines 63₁ to 63 _{$m/2$} respectively, and A/D convert pixel signals supplied via the vertical signal lines 63₁ to 63 _{$m/2$} by using a ramp signal supplied from DAC 56.

Each of the ADCs 64_1 to $64_{m/2}$ has a comparator, a counter, a switch, and a memory. Namely, ADC 64_1 has a comparator 65₁, a counter (CNT) 66₁, a switch 67₁, and a memory 68₁, ADC 64_2 has a comparator 65₂, a counter 66₂, a switch 67₂, and a memory 68₂, and in a similar manner to follow, ADC $64_{m/2}$ has a comparator 65 _{$m/2$} , a counter 66 _{$m/2$} , a switch 67 _{$m/2$} , and a memory 68 _{$m/2$} .

The pixel signals are supplied from the pixels $61_{m,1}$ to $61_{m,n}$ to the comparators 65₁ to 65 _{m} via the vertical signal lines 63₁ to 63 _{$m/2$} , and the ramp signal is supplied from DAC 56.

The comparators 65_1 to $65_{m/2}$ compare the ramp signal supplied from DAC 56 with the pixel signals supplied via the vertical signal lines 63_1 to $63_{m/2}$, and supply comparison signals representative of the comparison results to the counters 66_1 to $66_{m/2}$. Namely, the comparator 65_1 supplies a comparison signal between the ramp signal from DAC 56 and the pixel signals supplied from the pixels $61_{1,1}$ to $61_{1,n}$ and pixels $61_{2,1}$ to $61_{2,n}$ via the vertical signal line 63_1 , to the counter 66_1 .

The comparator 65_2 supplies a comparison signal between the ramp signal from DAC 56 and the pixel signals supplied from the pixels $61_{3,1}$ to $61_{3,n}$ and pixels $61_{4,1}$ to $61_{4,n}$ via the vertical signal line 63_2 , to the counter 66_2 , and in a similar manner to follow, the comparator $65_{m/2}$ supplies a comparison signal between the ramp signal from DAC 56 and the pixel signals supplied from the pixels $61_{m-1,1}$ to $61_{m-1,n}$ and pixels $61_{m,1}$ to $61_{m,n}$ via the vertical signal line $63_{m/2}$, to the counter $66_{m/2}$.

The counters 66_1 to $66_{m/2}$ are supplied with a clock signal from the timing control circuit 52, and count the clock signals on the basis of the comparison signal from the comparators 65_1 to $65_{m/2}$. The count values representative of the count results of clock signals by the counters 66_1 to $66_{m/2}$ are supplied to the memories 68_1 to $68_{m/2}$ via the switches 67_1 to $67_{m/2}$, as pixel data obtained by A/D conversion of the pixel signal.

In response to the timing signal from the timing control circuit 52, the switches 67_1 to $67_{m/2}$ couple the counters 66_1 to $66_{m/2}$ and the memories 68_1 and $68_{m/2}$, respectively.

The memories 68_1 to $68_{m/2}$ temporarily store the pixel data supplied from the counters 66_1 to $66_{m/2}$, and output the pixel data to the horizontal output line 59 under control of the column scanner 58.

The column scanner 58 sequentially outputs the pixel data stored in the memories 68_1 to $68_{m/2}$ to the horizontal output line 59 at a predetermined timing.

The horizontal output line 59 is connected to an image processing circuit or the like at the succeeding stage, and supplies the pixel data output from the memories 68_1 to $68_{m/2}$ to an image processing circuit and the like.

As described above, in the CMOS sensor 51, the pixels $61_{1,1}$ to $61_{m,n}$ of two columns at a time are connected to one vertical signal line 63, and the pixel signals of two columns are A/D converted by one ADC 64.

Next, with reference to FIG. 7, the 2x2 sharing pixel constituted of four pixels will be described.

As shown in FIG. 7, the 2x2 sharing pixel is constituted of four pixels $61a$ to $61d$. The pixel $61a$ is a pixel at the N-th row in an odd column, the pixel $61b$ is a pixel at the N-th row in an even column, the pixel $61c$ is a pixel at the (N+1)-th row in an odd column, and the pixel $61d$ is a pixel at the (N+1)-th row in an even column.

The pixel $61a$ includes a photodiode $71a$ and a transfer transistor $72a$, and the pixel $61b$ includes a photodiode $71b$ and a transfer transistor $72b$. The pixel $61c$ includes a photodiode $71c$ and a transfer transistor $72c$, and the pixel $61d$ includes a photodiode $71d$ and a transfer transistor $72d$.

In the 2x2 sharing pixel, the four pixels $61a$ to $61d$ share the reset transistor 73, amplifying transistor 74, select transistor 75, and floating diffusion 76. Namely, the photodiodes $71a$ to $71d$ are coupled to the floating diffusion 76 via the transfer transistors $72a$ to $72d$.

After the floating diffusion 76 is clamped to a predetermined reference potential in response to a reset signal RST (N) for controlling the reset transistor 73, the electric charge generated by the photodiode $71a$ is transferred to the floating diffusion 76 in response to a transfer signal TR1 (N) for

controlling the transfer transistor $72a$, and accumulated therein. The electric charge accumulated in the floating diffusion are outputted to the vertical signal line 63 via the select transistor 75, as a pixel signal of the pixel $61a$.

In succession to the output of the pixel signal of the pixel $61a$, after the floating diffusion 76 is clamped to a predetermined reference potential in response to the reset signal RST (N) for controlling the reset transistor 73, the electric charge generated by the photodiode $71b$ is transferred to the floating diffusion 76 in response to a transfer signal TR2 (N) for controlling the transfer transistor $72b$, and a pixel signal of the pixel $61b$ is outputted to the vertical signal line 63 similar to the pixel $61a$. In a similar manner to follow, the electric charge generated by the photodiode $71c$ is transferred to the floating diffusion 76, and a pixel signal of the pixel $61c$ is outputted to the vertical signal line 63, and the electric charge generated by the photodiode $71d$ is transferred to the floating diffusion 76, and a pixel signal of the pixel $61d$ is outputted to the vertical signal line 63.

As described above, in the 2x2 sharing pixel constituted of four pixels $61a$ to $61d$, the floating diffusion 76 and vertical signal line 63 are provided for the pixels $61a$ to $61d$.

FIG. 8 is a timing chart illustrating the operation of the CMOS sensor 51.

As a 1 H period for reading pixel signals at the N-th row starts, a select signal SEL (N) for controlling the select transistor 75 shown in FIG. 7 transits from an L level to an H level to start reading pixel signals from the 2x2 sharing pixel constituted of four pixels $61a$ to $61d$ shown in FIG. 7.

After the select signal SEL (N) transits from the L level to the H level, a reset signal RST (N) for controlling the reset transistor 73 becomes H level with a pulsed form, and in response to this reset signal RST (N), the floating diffusion 76 is clamped to a predetermined reference potential to perform A/D conversion at a reset level (P phase).

Thereafter, a transfer signal TR1 (N) for controlling the transfer transistor $72a$ becomes H level with a pulsed form, and in response to the transfer signal TR1 (N), the electric charge generated by the photodiode $71a$ of the pixel $61a$ is transferred to the floating diffusion 76 to perform A/D conversion at a data level (D phase).

The A/D conversion at the reset level and the A/D conversion at the data level will be described herebelow.

As shown in the second lowermost field of FIG. 8, when the floating diffusion 76 is clamped to the predetermined reference potential, a pixel signal corresponding to the reference potential is outputted. Thereafter, as the electric charges generated by the photodiode $71a$ are transferred to the floating diffusion 76, a pixel signal corresponding to the electric charges is outputted.

The pixel signal is inputted to one terminal of the comparator 65 (FIG. 6) via the select transistor 75 and vertical signal line 63. A ramp signal shown in the lowermost field of FIG. 8 is supplied to the other terminal of the comparator 65.

The comparator 65 compares the pixel signal with the ramp signal after the potentials at the input terminals are reset by internally shortening both the input terminals. The comparator 65 supplies a comparison result signal representative of the comparison result to the counter 66. For example, the comparator 65 outputs an L level comparison result signal if the pixel signal is not smaller than the ramp signal, and an H level comparison result signal if the pixel level is smaller than the ramp signal. Namely, the comparator 65 outputs a comparison result signal which transits from the H level to L level when the ramp signal becomes equal to the pixel signal while the voltage of the ramp signal lowers at a constant slope.

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While the pixel signal at the reset level is outputted, the counter 66 uses a count value (time) from the time when the ramp signal starts lowering at a constant slope and the time when the comparison result signal transits from the H level to L level, as an A/D conversion value of the pixel signal at the reset level. While the pixel signal at the data level is output, the counter 66 uses a count value from the time when the ramp signal starts lowering at a constant slope and the time when the comparison result signal transits from the H level to L level, as an A/D conversion value of the pixel signal at the data level.

A difference between the A/D conversion value of the pixel signal at the reset level and the A/D conversion value of the pixel signal at the data level is stored in the memory 68 (FIG. 6) as pixel data.

In the manner described above, the pixel data read from the pixel 61a is A/D converted and the pixel data of the pixel 61a is stored in the memory 68. Thereafter, the reset signal RST (N) for controlling the reset transistor 73 becomes H level with a pulsed form, and in response to this reset signal RST (N), the floating diffusion 76 is clamped to the predetermined reference potential. Namely, the electric charge generated by the photodiode 71a of the pixel and accumulated in the floating diffusion 76 are reset.

Thereafter, a transfer signal TR2 (N) for controlling the transfer transistor 72b becomes H level with a pulsed form, and in response to the transfer signal TR2 (N), the electric charge generated by the photodiode 71b of the pixel 61b is transferred to the floating diffusion 76. Thereafter, similar to the A/D conversion of the pixel signal read from the pixel 61a, a pixel signal read from the pixel 61b is A/D converted. In parallel with the A/D conversion of the pixel signal of the pixel 61b, the pixel data of the pixel 61a stored in the memory 68 is outputted to the horizontal output line 59 under control of the column scanner 58.

After the 1 H period for reading pixel signals at the N-th line ends, another 1 H period for reading pixel signals at the (N+1)-th line starts. The reset signal RST (N) for controlling the reset transistor 73 becomes H level with a pulsed form to reset the electric charge generated by the photodiode 71b of the pixel 61b and accumulated in the floating diffusion 76.

Thereafter, a transfer signal TR3 (N) for controlling the transfer transistor 72c becomes H level with a pulsed form, and in response to the transfer signal TR3 (N), the electric charge generated by the photodiode 71c of the pixel 61c is transferred to the floating diffusion 76. In parallel with the A/D conversion of the pixel signal of the pixel 61c, the pixel data of the pixel 61b stored in the memory 68 is outputted to the horizontal output line 59 under control of the column scanner 58.

Thereafter, the reset signal RST (N) for controlling the reset transistor 73 becomes H level with a pulsed form to reset the electric charge generated by the photodiode 71c of the pixel 61c and accumulated in the floating diffusion 76.

Thereafter, a transfer signal TR4 (N) for controlling the transfer transistor 72d becomes H level with a pulsed form, and in response to the transfer signal TR4 (N), the electric charge generated by the photodiode 71d of the pixel 61d is transferred to the floating diffusion 76. In parallel with the A/D conversion of the pixel signal of the pixel 61d, the pixel data of the pixel 61c stored in the memory 68 is outputted to the horizontal output line 59 under control of the column scanner 58. The pixel data of the pixel 61d stored in the memory 68 is outputted to the horizontal output line 59 during the next 1 H period.

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As described above, in the CMOS sensor 51, ADC 64 performs A/D conversion twice during the 1 H period to output pixel data of one row.

As shown in the uppermost field of FIG. 8, the CMOS sensor 51 reads the pixel signal and performs the A/D conversion in the order of the pixel 61a at the N-th row in the odd column, pixel 61b at the N-th row in the even column, pixel 61c at the (N+1)-th row in the odd column and pixel 61d at the (N+1)-th row in the even column. The pixel data is outputted to the horizontal output line in the order of the pixel 61a at the N-th row in the odd column, pixel 61b at the N-th row in the even column, pixel 61c at the (N+1)-th row in the odd column and pixel 61d at the (N+1)-th row in the even column. Namely, in the CMOS sensor 51, since the pixel data in the odd column is outputted and then the pixel data in the even column is outputted, the processing circuit at the succeeding stage rearranges the order of pixel data to make the pixel data have the same order of pixels to thereby form an image.

Since one ADC 64 performs the A/D conversion of pixel signals of two columns, ADCs 64₁ to 64_{m/2} can be disposed in parallel at a pitch twice that of the pixels 61_{1,1} to 61_{m,n}. Even if the pitch of the pixels 61_{1,1} to 61_{m,n} is narrow, ADCs 64₁ to 64_{m/2} can be laid out easily. The number of ADCs 64 can be halved as compared to the case in which ADC 64 is not shared by pixels of two columns. Since the area of the column processing unit 57 is reduced, the CMOS sensor 51 can be made compact. Since the number of ADCs 64 is reduced, it is advantageous to the streaking characteristics such as stripes appearing on an image.

Further, as described with reference to FIG. 7, since the four pixels 61a to 61d share the reset transistor 73, amplifying transistor 74, and select transistor 75, the number of transistors can be reduced as compared to the case in which these transistors are not shared. It is therefore possible to improve the photographing characteristics such as the saturated charge amount and the sensitivity. Even if the CMOS sensor 51 is made compact, it is possible to suppress an image quality from being degraded, by increasing an aperture ratio of each pixel.

Furthermore, in the CMOS sensor 51, as described with reference to FIG. 3, the image quality degradation to be caused by disposing the column processing unit in two areas does not occur. In addition, a problem to be caused by holding analog pixel signals in capacitors as described with reference to FIG. 4 does not occur.

In the CMOS sensor 51, as described above, a pixel value is sequentially read from each pixel, and in addition, the electric charges outputted from a plurality of pixels are added together by the floating diffusion 76 so that a pixel signal corresponding to the added electric charges can be read.

FIG. 9 is a timing chart illustrating another example of the operation of the CMOS sensor 51.

With reference to FIG. 9, description will be made on an example of addition of electric charges of two pixels disposed in a horizontal direction, e.g., addition of electric charges of the pixels 61a and 61b shown in FIG. 7 and addition of electric charges of the pixels 61c and 61d.

After a select signal SEL (N) transits from an L level to an H level, a reset signal RST (N) becomes H level with a pulsed form, and the floating diffusion 76 is clamped to a predetermined reference potential to perform A/D conversion at the reset level.

Thereafter, a transfer signal TR1 (N) and a transfer signal TR2 (N) become H level with a pulsed form at the same time, and in response to the transfer signal TR1 (N) and transfer

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signal TR2 (N), electric charges generated by the photodiodes **71a** and **71b** are transferred to the floating diffusion **76** at the same time.

At the result, in the floating diffusion **76**, electric charges generated by the photodiodes **71a** and **71b** are added, and by using a pixel signal corresponding to the added electric charges, the A/D conversion at the data level is performed. A difference between the A/D conversion value at the reset level and the A/D conversion value at the data level is stored in the memory **68** as pixel data.

After the 1 H period for reading pixel signals of the N-th row ends, the reset signal RST (N) becomes H level with a pulsed form, and the floating diffusion **76** is clamped to the predetermined reference potential, i.e. the accumulated charges are reset, to perform the A/D conversion at the reset level.

Thereafter, similar to the A/D conversion of the pixel signal obtained through addition of the photodiodes **71a** and **71b**, electric charges generated by the photodiodes **71c** and **71d** are added, and by using a pixel signal corresponding to the added electric charges, the A/D conversion at the data level is performed.

In parallel with the A/D conversion of the pixel signal obtained through addition of the photodiodes **71c** and **71d**, pixel data obtained by the A/D conversion of the pixel signal obtained through addition of the photodiodes **71a** and **71b** is outputted from the memory **68** to the horizontal output line **59**. The pixel data obtained by the A/D conversion of the pixel signal obtained through addition of the photodiodes **71c** and **71d** is outputted during the next 1 H period.

As described above, electric charges from two pixels are added at the floating diffusion **76**, and a pixel signal corresponding to the added electric charges is read. It is therefore possible to double a frame rate at which an image is photographed.

Since electric charges are added at the floating diffusion **76**, the number of AD conversion processes can be reduced and noises can be reduced, for example, as compared to the case in which pixel signals from two pixels are A/D converted and thereafter the pixel data is added digitally. More specifically, since noises contained in an image signal increase by square in an A/D conversion process, noises of the amplifying transistor **74** and noises of ADC **64** can be reduced by $1/\sqrt{2}$, in correspondence with a reduction in the number of A/D conversion processes.

FIG. 10 is a block diagram showing an example of the structure of a CMOS sensor according to another embodiment.

In FIG. 10, a CMOS sensor **51'** includes a timing control circuit **52**, a row scanner **53**, a pixel array **54**, m/2 load MOSs **55₁** to **55_{m/2}**, a DAC **56**, a column processing unit **57'**, a column scanner **58**, and a horizontal output line **59**. In FIG. 10, similar components to those of the CMOS sensor **51** shown in FIG. 6 are represented by identical reference symbols, and the description thereof is omitted in the following where appropriate.

Namely, the CMOS sensor **51'** shown in FIG. 10 is similar to the CMOS sensor **51** shown in FIG. 6 in that the CMOS sensor **51'** includes the timing control circuit **52**, row scanner **53**, pixel array **54**, m/2 load MOSs **55₁** to **55_{m/2}**, DAC **56**, a column scanner **58**, and a horizontal output line **59**. The CMOS sensor **51'** includes the column processing unit **57'** which is different from that of the CMOS sensor **51**.

The column processing unit **57'** includes m/2 ADCs **64₁** to **64_{m/2}** disposed in parallel. Each of the ADCs **64₁** to **64_{m/2}** includes a comparator, a counter, two switches, and two memories.

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Namely, the ADC **64₁** includes a comparator **65₁**, a counter (CNT) **66₁**, two switches **67₁'** and **67₂'**, and two memories **68₁'** and **68₂'**. The ADC **64₂** includes a comparator **65₂**, a counter **66₂**, two switches **67₃'** and **67₄'**, and two memories **68₃'** and **68₄'**, and in a similar manner to follow, the ADC **64_{m/2}** includes a comparator **65_{m/2}**, a counter **66_{m/2}**, two switches **67_{m-1}'** and **67_m'**, and two memories **68_{m-1}'** and **68_m'**.

In the CMOS sensor **51'** constructed as above, for example, pixel data of pixels in an odd column and pixel data of pixels in an even column among the pixels **61_{1,1}** to **61_{m,n}** can be stored in different memories.

For example, during the 1 H period for reading the pixels **61_{1,N}** to **61_{m,N}** at the N-th rows, as the counter **66₁** of ADC **64₁'** A/D converts a pixel signal of the pixel **61_{1,N}** in the first column, the switch **67₁'** is coupled to the memory **68₁'**, and pixel data of the pixel **61_{1,N}** in the first column is stored in the memory **68₁'**. As the counter **66₁** performs A/D conversion of a pixel signal of the pixel **61_{2,N}** in the second column, the switch **67₂'** is coupled to the memory **68₂'**, and pixel data of the pixel **61_{2,N}** in the second column is stored in the memory **68₂'**.

Similarly, in ADC **64₂'**, the pixel data of the pixel **61_{3,n}** in the third column is stored in the memory **68₃'**, and pixel data of the pixel **61_{4,n}** in the fourth column is stored in the memory **68₄'**. In ADC **64_m'**, the pixel data of the pixel **61_{m-1,n}** in the (m-1) column is stored in the memory **68_{m-1}'**, and pixel data of the pixel **61_{m,n}** in the m-th column is stored in the memory **68_m'**.

As described above, by storing pixel data of pixels in an odd column and pixel data of pixels in an even column in different memories, pixel data of the pixel **61_{1,N}** in the first column to pixel data of the pixel **61_{m,n}** in the m-th column can be outputted sequentially to the horizontal output line **59**, under control of the column scanner **58**.

Namely, as described with reference to FIG. 8, in the CMOS sensor **51**, a pixel data order rearrangement process is performed by a processing circuit at the succeeding stage to rearrange the order of pixels. In the CMOS sensor **51'**, the pixel data is outputted in the order of pixels. As a result, it is not necessary to perform the rearrangement process of pixel data order.

FIG. 11 is a timing chart illustrating an example of the operation of the CMOS sensor **51'**.

As shown in FIG. 11, during the 1 H period for reading pixel signals at the N-th row, a pixel signal of the pixel **61a** at the N-th row in an odd column is read, and thereafter a pixel signal of the pixel **61b** at the N-th row in an even column is read. Thereafter, during the 1 H period for reading pixel signals at the (N+1)-th row, a pixel signal of the pixel **61c** at the (N+1)-th row in an odd column is read, and thereafter in parallel with reading a pixel signal of the pixel **61d** at the (N+1)-th row in an even column, pixel data at the N-th row is output in the order of pixels. Pixel data at the (N+1)-th row is outputted in the order of pixels during the next 1 H period. In FIG. 11, the select signal SEL (N), the reset signal RST (N), the transfer signals TR1 to TR4, the pixel signal and the ramp signal are the same as those shown in the timing chart of FIG. 8.

In embodiments of the present invention, the 2×2 sharing pixel in which vertical two pixels×horizontal two pixels **61a** to **61d** share the amplifying transistor and the like has been described. For example, in order to make the pitch of ADCs broader than that of pixels, it is sufficient if at least a plurality of pixels in the horizontal direction share the amplifying transistor and the like. Namely, even if the sharing pixel having two pixels in the horizontal direction shares the ampli-

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fying transistor and the like, ADCs can be laid out easily similar to the 2x2 sharing pixel.

Embodiments of the present invention are not limited only to the above-described embodiments, but various modifications are possible without departing from the gist of the present invention.

What is claimed is:

1. An image pickup apparatus comprising:

a plurality of photoelectric conversion circuits configured to convert incident light into an electric charge and accumulate the electric charge, wherein each of the plurality of photoelectric conversion circuits is further configured to provide a pixel signal corresponding to the accumulated electric charge;

a plurality of pixel transistors, wherein each of the plurality of pixel transistors is electrically connected to at least one of the photoelectric conversion circuits;

a plurality of control lines, wherein each of the plurality of control lines is electrically connected to a gate of each of the plurality of the pixel transistors; and

a plurality of analog-to-digital (A/D) conversion circuits, wherein each of the plurality of A/D conversion circuits is shared between at least two columns of the plurality of photoelectric conversion circuits;

wherein,

at least one A/D conversion circuit of the plurality of A/D conversion circuits is configured to perform one or more A/D conversions of a first pixel signal obtained by adding at a shared floating diffusion region a pixel signal provided by each of a first plurality of the photoelectric conversion circuits included in a first pixel row of a common unit, and to perform one or more A/D conversions of a second pixel signal obtained by adding at the shared floating diffusion region a pixel signal provided by each of a second plurality of the photoelectric conversion circuits included in a second pixel row of the common unit,

the common unit includes at least two photoelectric conversion circuits in each row and at least two photoelectric conversion circuits in each column, and the at least two photoelectric conversion circuits in each row and the at least two photoelectric conversion circuits in each column share at least one pixel transistor, and

at least one control line of the plurality of control lines is disposed in a horizontal direction.

2. The image pickup apparatus according to claim 1, wherein the at least one A/D conversion circuit of the plurality of A/D conversion circuits is configured to perform one or more A/D conversions of the first pixel signal obtained by adding at the shared floating diffusion region the pixel signal provided by each of a first plurality of the photoelectric conversion circuits included in a first pixel row of a common unit during a first scan period of reading the pixel signal in a horizontal direction, and to perform one or more A/D conversions of the second pixel signal obtained by adding at the shared floating diffusion region the pixel signal provided by each of a second plurality of the photoelectric conversion circuits included in a second pixel row of the common unit during a second scan period of reading the pixel signal in the horizontal direction.

3. The image pickup apparatus according to claim 1, wherein the common unit shares an amplifier transistor.

4. The image pickup apparatus according to claim 3, wherein the common unit shares a reset transistor.

5. The image pickup apparatus according to claim 4, wherein the common unit shares a select transistor and a

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control line connected to the select transistor and a control line connected to the reset transistor are disposed in a horizontal direction.

6. The image pickup apparatus according to claim 3, further comprising:

a plurality of transfer transistors, wherein at least one of the plurality of photoelectric conversion circuits is electrically connected to at least one transfer transistor of the plurality of transfer transistors.

7. The image pickup apparatus according to claim 6, further comprising a control line for transmitting a signal for controlling a transfer of the accumulated electric charge, wherein the control line is independent for each of the plurality of the transfer transistors of the common unit sharing the amplifier transistor.

8. The image pickup apparatus according to claim 3, wherein the common unit shares a select transistor and a control line connected to the select transistor is disposed in a horizontal direction.

9. The image pickup apparatus according to claim 1, wherein a pitch of the at least one A/D conversion circuit is twice as wide as the photoelectric conversion circuit in the horizontal direction.

10. The image pickup apparatus according to claim 1, wherein the at least one A/D conversion unit further comprises:

a comparison unit having a first input terminal for receiving the first pixel signal and a second input terminal for receiving a reference voltage, the comparison unit comparing the first pixel signal provided at the first input terminal with the reference voltage provided at the second input terminal; and

a measurement unit for measuring a time from when the reference voltage changes from a predetermined reference potential to when the comparison unit judges that the reference voltage is within a predetermined range of the first pixel signal.

11. The image pickup apparatus according to claim 1, wherein the at least one A/D conversion circuit outputs the first pixel signal converted into a digital signal in an order of the photoelectric conversion circuit in the horizontal direction.

12. The image pickup apparatus according to claim 1, wherein the floating diffusion region is shared by two photoelectric conversion circuits in each row and two photoelectric conversion circuits in each column, and disposed in a center of the two photoelectric conversion circuits in each row and two photoelectric conversion circuits in each column.

13. The image pickup apparatus according to claim 1, wherein the plurality of pixel transistors include at least a reset transistor, an amplifier transistor, a transfer transistor, and a select transistor.

14. The image pickup apparatus according to claim 1, wherein the plurality of the control lines include a first control line and a second control line and the plurality of pixel transistors includes a first transistor and a second transistor;

wherein, the first control line is electrically connected to a gate of the first pixel transistor and the second control line is electrically connected to a gate of the second pixel transistor.

15. An image pickup apparatus for photographing an image, the image pickup apparatus comprising:

a plurality of photoelectric converters, each of the plurality of photoelectric converters configured to convert incident light into an electric charge and accumulate the electric charge, wherein each of the plurality of photo-

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electric converters is further configured to provide a pixel signal corresponding to the accumulated electric charge;

a plurality of the pixel transistors, wherein each of the plurality of pixel transistors is electrically connected to at least one of the photoelectric converters;

a plurality of control lines, wherein each of the plurality of control lines is electrically connected to a gate of each of the plurality of the pixel transistors; and

a plurality of analog-to-digital (A/D) converters, wherein each of the plurality of A/D converters is shared between at least two columns of the plurality of photoelectric converters; and

wherein,

at least one A/D converter of the plurality of A/D converters is configured to perform one or more A/D conversions of a first pixel signal obtained by adding at a shared floating diffusion region a pixel signal provided by each of a first plurality of the photoelectric converters included in a first pixel row of a common unit, and to perform one or more A/D conversions of a second pixel signal obtained by adding at the shared floating diffusion region a pixel signal provided by each of a second plurality of the photoelectric converters included in a second pixel row of the common unit,

the common unit includes at least two photoelectric converters in each row and at least two photoelectric converters in each column and the at least two photoelectric converters in each row and the at least two photoelectric converters in each column share at least one pixel transistor, and

at least one control line of the plurality of control lines is disposed in a horizontal direction.

16. The image pickup apparatus according to claim **15**, wherein the at least one A/D converter of the plurality of A/D converters is configured to perform one or more A/D conversions of the first pixel signal obtained by adding at the shared floating diffusion region the pixel signal provided by each of a first plurality of the photoelectric converters included in a first pixel row of a common unit during a first scan period of reading the pixel signal in a horizontal direction, and perform one or more A/D conversions of the second pixel signal

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obtained by adding at the shared floating diffusion region the pixel signal from each of a second plurality of the photoelectric converters included in a second pixel row of the common unit during a second scan period of reading a pixel signal in the horizontal direction.

17. The image pickup apparatus according to claim **15**, wherein the common unit shares an amplifier transistor, and a reset transistor.

18. The image pickup apparatus according to claim **17**, further comprising:

a plurality of transfer transistors, wherein at least one of the plurality of photoelectric converters is electrically connected to at least one transfer transistor of the plurality of transfer transistors.

19. The image pickup apparatus according to claim **18**, further comprising a control line for transmitting a signal for controlling a transfer of the accumulated electric charge, wherein the control line is independent for each of the plurality of the transfer transistors of the common unit sharing the amplifier transistor.

20. The image pickup apparatus according to claim **15**, wherein a pitch of the at least one A/D converter is twice as wide as the photoelectric converter in the horizontal direction.

21. The image pickup apparatus according to claim **15**, wherein the at least one A/D converter further comprises:

a comparison unit having a first input terminal for receiving the first pixel signal and a second input terminal for receiving a reference voltage, the comparison unit comparing the first pixel signal provided at the first input terminal with the reference voltage provided at the second input terminal; and

a measurement unit for measuring a time from when the reference voltage changes from a predetermined reference potential to when the comparison unit judges that the reference voltage is within a predetermined range of the first pixel signal.

22. The image pickup apparatus according to claim **15**, wherein the at least one A/D converter outputs the first pixel signal converted into a digital signal in an order of the photoelectric converter in the horizontal direction.

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